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NEW PATHWAY TO REGULATE NITRATE ABSORPTION IN PLANTS

Relevant for: Science & Technology | Topic: Biotechnology, Genetics & Health related developments

Approach: The researchers used rice and tobacco plants to study the mechanism. | Photo Credit: Special Arrangement

Researchers led by those from the National Centre of Biological Sciences, Tata Institute of Fundamental Research, Bengaluru (NCBS-TIFR), have found a new pathway that regulates nitrate absorption in plants.

The gene MADS27, which regulates nitrate absorption, root development and stress tolerance, is activated by the micro-RNA, miR444, therefore offers a way to control these properties of the plant.

The researchers studied this mechanism in both rice (monocot) and tobacco (dicot) plants. The research is published in *Journal of Experimental Botany.*

Nitrogen is one of the most important macronutrients needed for development of a plant. It is a part of chlorophyll, amino acids and nucleic acids, among others. It is mostly sourced from the soil where it is mainly absorbed in the form of nitrates and ammonium by the roots. Nitrates also play a role in controlling genome-wide gene expression that in turn regulates root system architecture, flowering time, leaf development, etc.

Thus, while a lot of action takes place in the roots to absorb and convert nitrogen into useful nitrates, the absorbed nitrates in turn regulate plant development apart from being useful as a macronutrient.

So, the presence of nitrates is important for the plant development and also for grain production. However, the overuse of nitrates in fertilizers, for instance, can lead to the dumping of nitrates in the soil which leads to accumulation of nitrates in water and soil. This accumulation adds to soil and water pollution and increased contribution to greenhouse gases.

To avoid this, there should be optimal use of nitrates. Also, since the whole process of nitrate absorption takes place in the roots, a well-developed root system is needed for this to take place optimally.

At one level, it is known that the hormone auxin is responsible for well-developed roots across all plants. A number of genes are known to help with auxin production, improved nitrate transport and assimilation in plants.

In addition to this route, several gene regulatory switches that regulate nitrate absorption and root development, such as the micro-RNA, miR444, are known in monocot plants, such as rice.

“The micro-RNA ‘miR444’ is specific to monocots. When this is not made, its target, MADS27, is produced in higher abundance, and it improves biosynthesis and transport of the hormone auxin, which is key for root development and its branching,” says Dr. P.V. Shivaprasad, who led the researchers at National Centre for Biological Sciences, Tata Institute of Fundamental Research, Bengaluru (NCBS-TIFR).

This regulatory miR444 switch is known to turn off at least five genes called MADS box transcription factor genes. The speciality of the MADS box transcription factors is that they function like switch boxes of their own. They bind to their favourite specific DNA sequences and they switch the neighbouring genes “on.”

The researchers have studied a target gene of miR444 called MADS27, a transcription factor which hasn’t been studied well before.

They have found that this transcription factor has a three-pronged effect on the plant.

First, it regulates nitrate absorption by switching “on” proteins involved in this process. Second, it leads to better development of the roots by regulating auxin hormone production and transport. Finally, and somewhat surprisingly to the researchers, it helps in the abiotic stress tolerance by keeping the main stress player proteins “on.”

“This is a new finding with a three-pronged effect and it provides an alternate means of regulating and optimising nitrate absorption,” says Dr. Shivaprasad.

Wanting to test this in dicot plants as well, the researchers carried out the study on tobacco plants as well. “We realised MADS27 works to improve three factors — nitrate absorption, root development and stress tolerance — with the help of RNA analysis and after finding to which part of the genome this transcription factor binds,” explains Dr. Shivaprasad.

According to the researchers, the gene MADS27 appears to be an excellent candidate to modify, in order to develop nitrogen use efficiency, which is something that helps the plant absorb more nitrates, and to engineer abiotic stress tolerance.

“Tinkering MADS27 expression by genome editing is the next step, so that the modified plants are acceptable to use directly,” he adds. The larger goal of this study is to understand how epigenetics plays a role in regulating expression of such important genes.

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